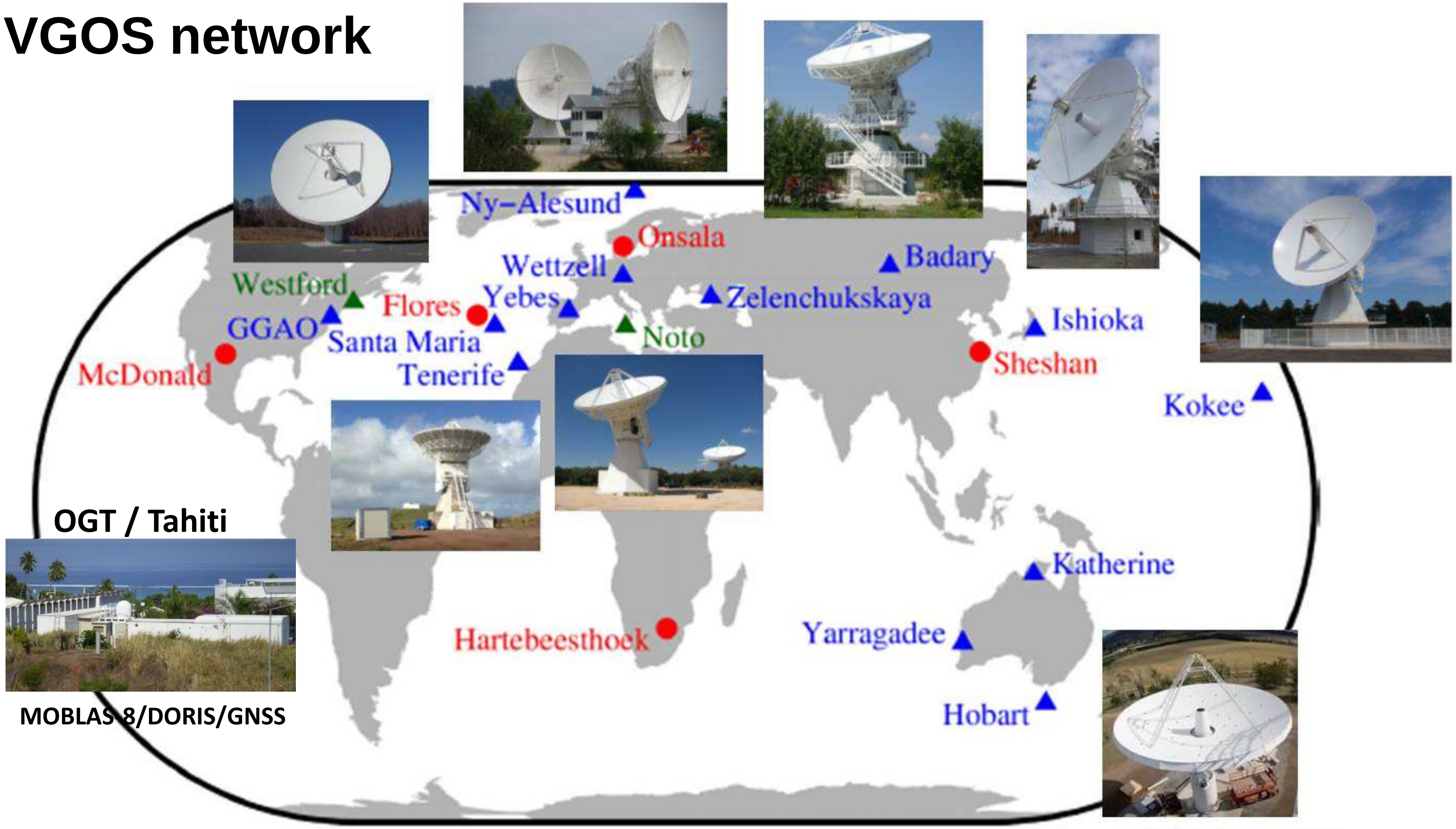
# Plan for a VLBI antenna in Tahiti from 2018

*Richard BIANCALE, Centre National d'Etudes Spatiales, France,*

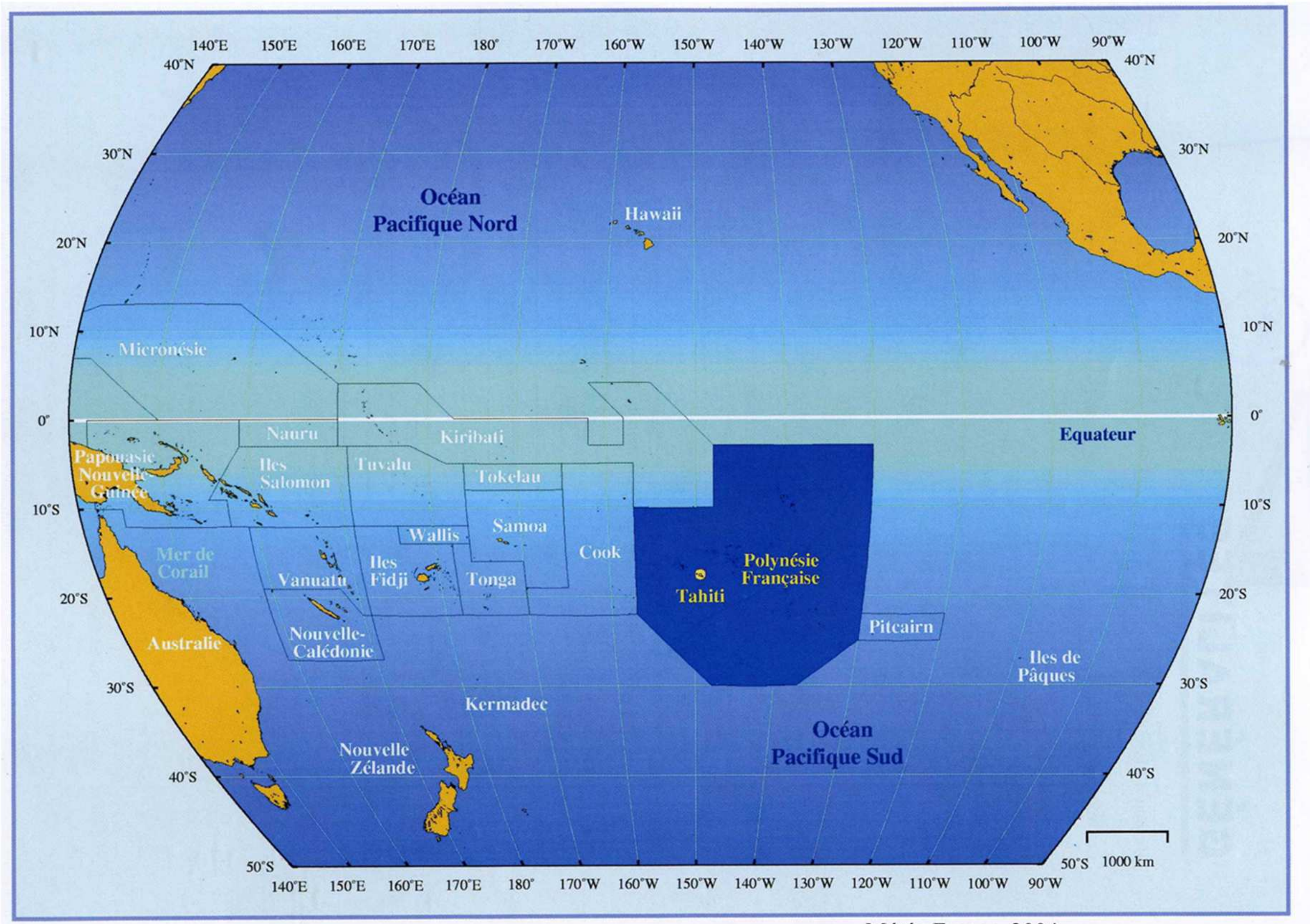
*Jean-Pierre BARRIOT, Université de la Polynésie Francaise, French Polynesia*

# VGOS network




*Source: Dirk Behrend, 2015*

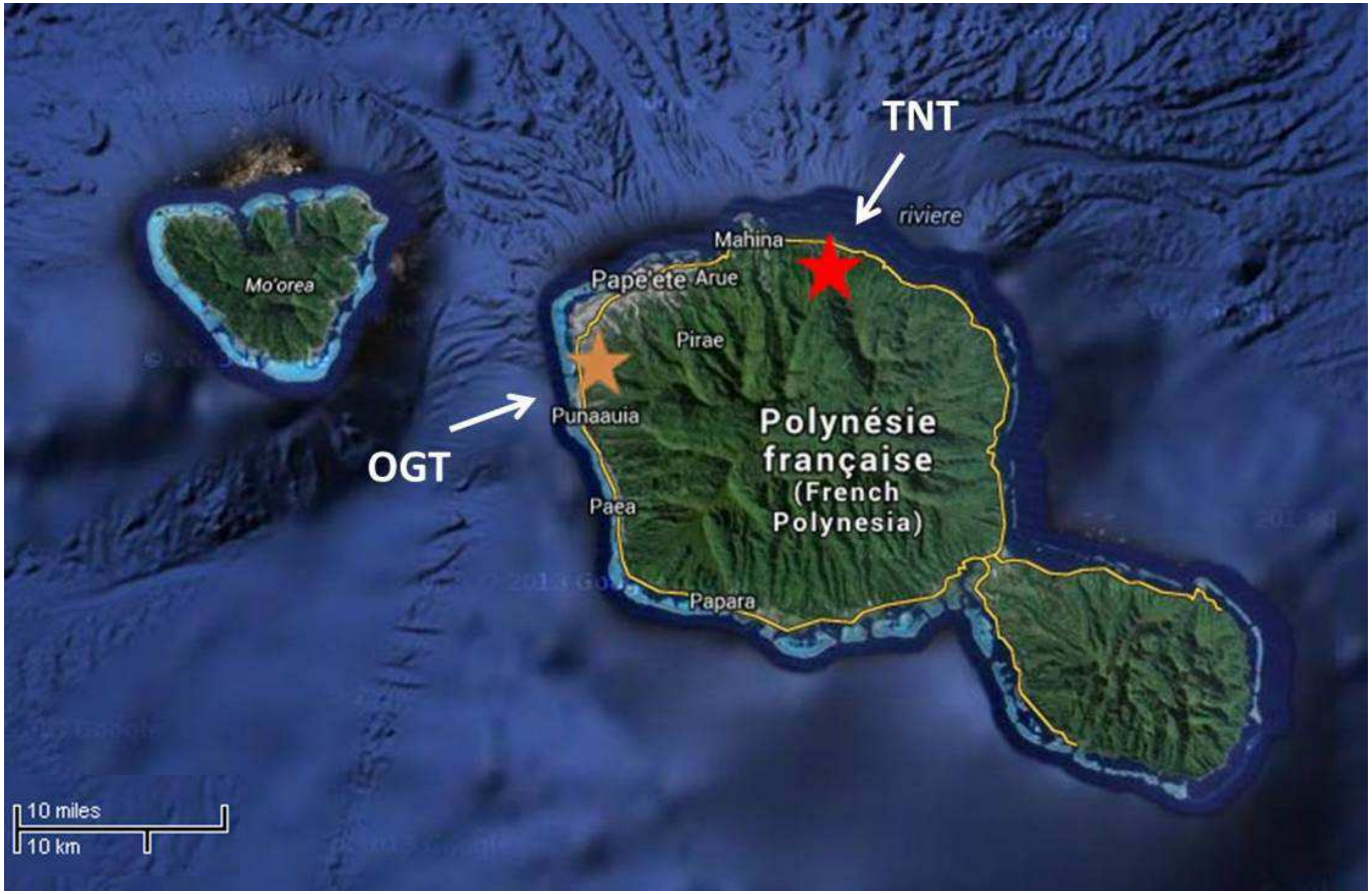
VGOS progress:
- ▲ hardware work in progress
- ● funding approved
- ▲ legacy upgrade in progress




Météo France, 2004

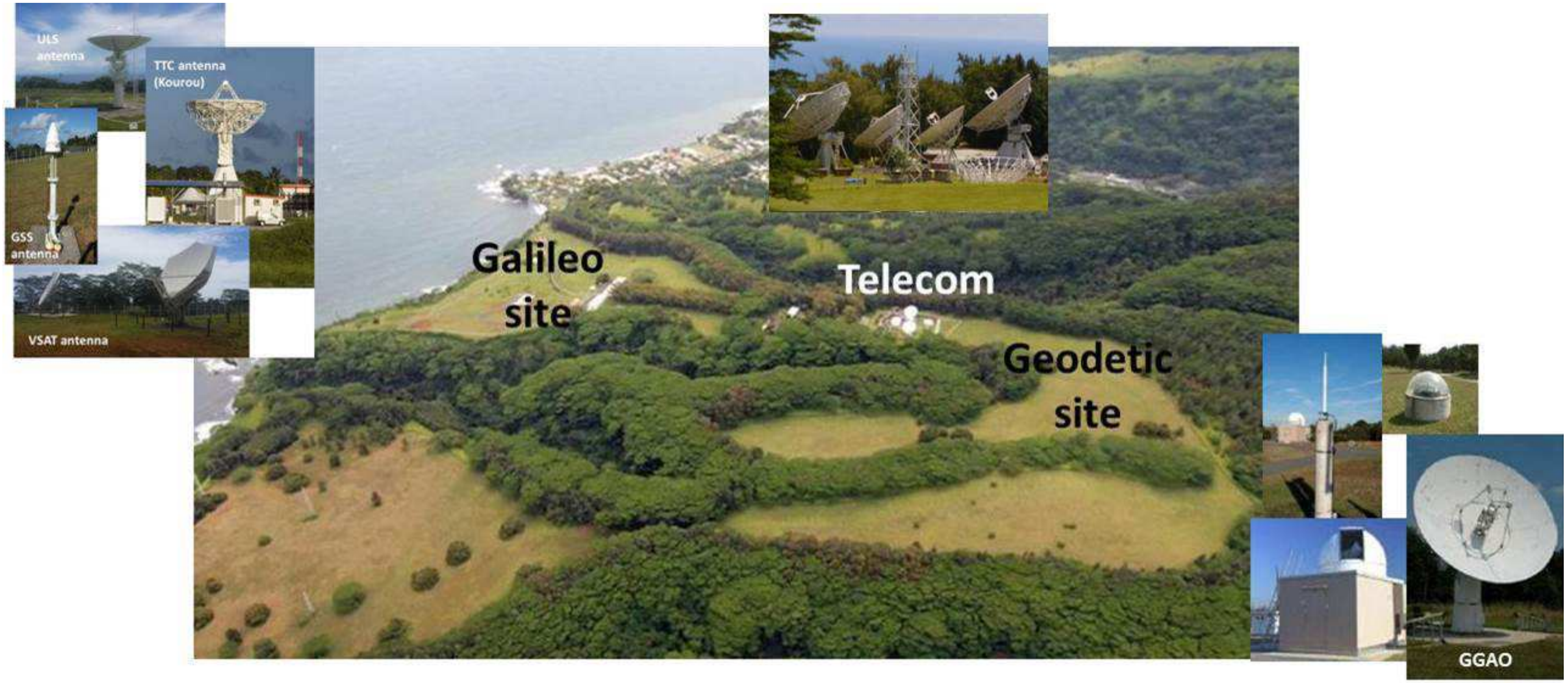
French territory
Maritime area: 5.5 $10^6$ $km^2$ (half so large as Europe or USA)
Land area: 3 500 $km^2$ (118 islands and atolls,76 inhabited, 280 000 inhabitants)

# The Tahiti Nui Telecom (TNT) site



# The Tahiti Nui Telecom site

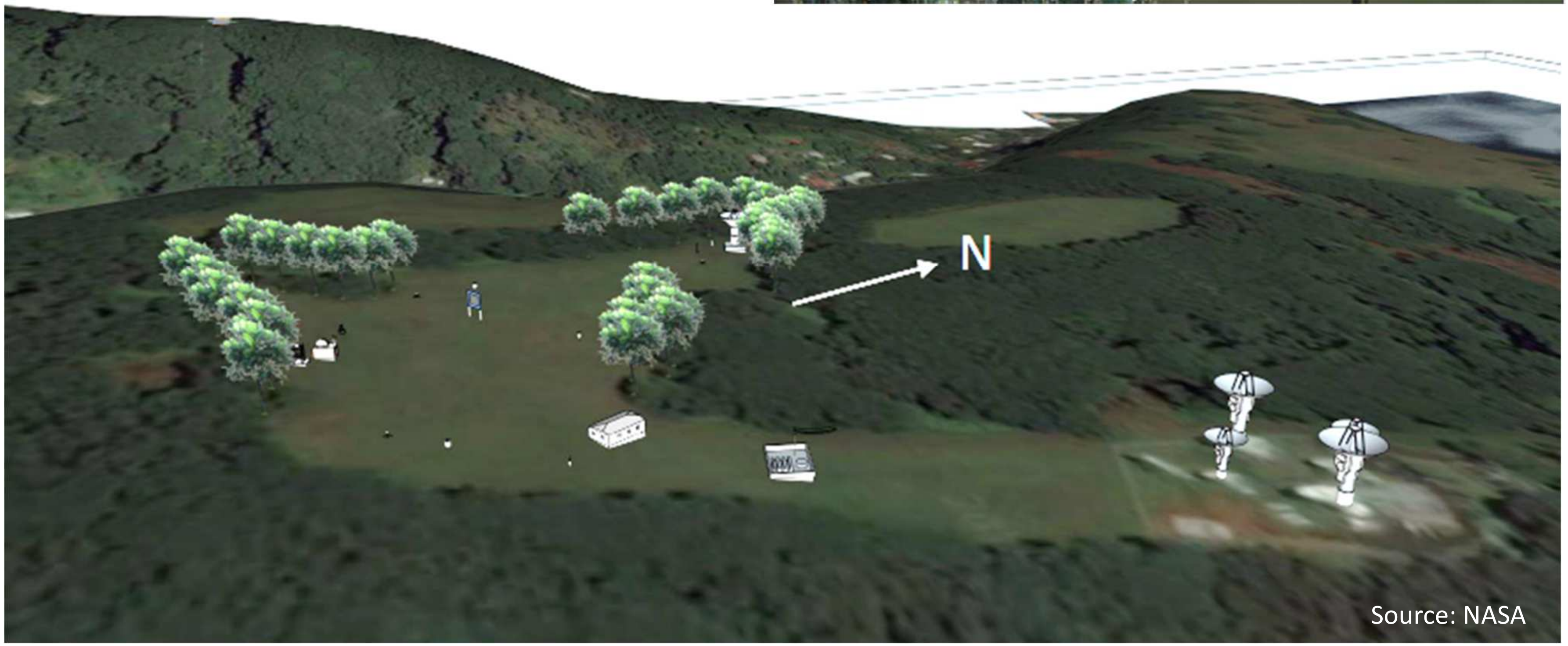
- Tahiti Nui Telecom (TNT) expressed its agreement in principle for hosting instruments of space geodesy on its ground in Papenoo for a 30 year period at least.




- The site of Papenoo benefits from a recognized natural and physical protection. It already hosts the chief station of satellite reception in Tahiti (4.2 and 6 GHz), a ground station of the Galileo system (1.5 and 5.2 GHz) as well as the Tahitian extremity of the international Honotua submarine fiber from the Hawaiian Islands.

# NASA layout proposal

- ~3 ha site in the South clearing of the Atohei plateau belonging to TNT (72 ha)
- 17.5178°S, 149.4370°W, 200m alt.
- NASA will expertise the site in April 2016 (RFI tests)



# VLBI simulations

A VLBI antenna in Tahiti would complete profitably the GGOS network . The plan is to rely on the development and installation of a new NASA VGOS antenna in 2018 in the framework of the CNES-NASA cooperation on space geodesy activities (NASA-CNES Implementing Arrangement, 2014).

Some simulation studies were already performed (eg from D. MacMillan, NASA/GSFC, 2010):

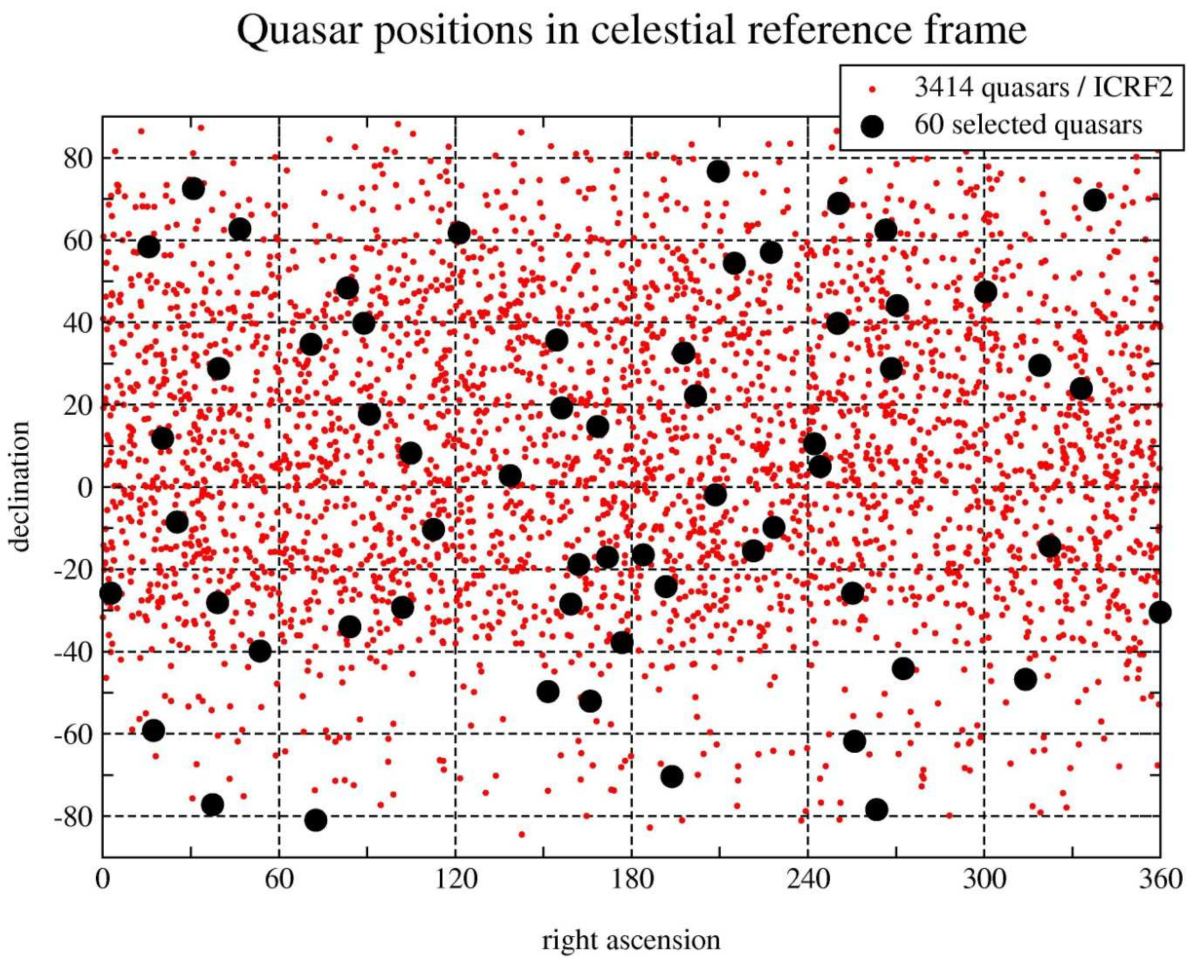
*- adding Tahiti to a 8-station network (Hobart, Kokee, Canary Isl., NyAlesund, Tsukuba, GGAO, Wettzell, Badary) improves EOP precision by 25%,*

*- taking into account a set of 15-station globally distributed network, adding Tahiti improves EOP precision by 13%.*

The CNES/GRGS GINS software is able to simulate all kinds of space geodesy measurements. This feature was used to estimate the impact of an additional VLBI antenna in Tahiti taking into account a limited set of 12 VLBI antennas well distributed all over the world with a set of 60 quasar sources.

# Set of quasars for simulations

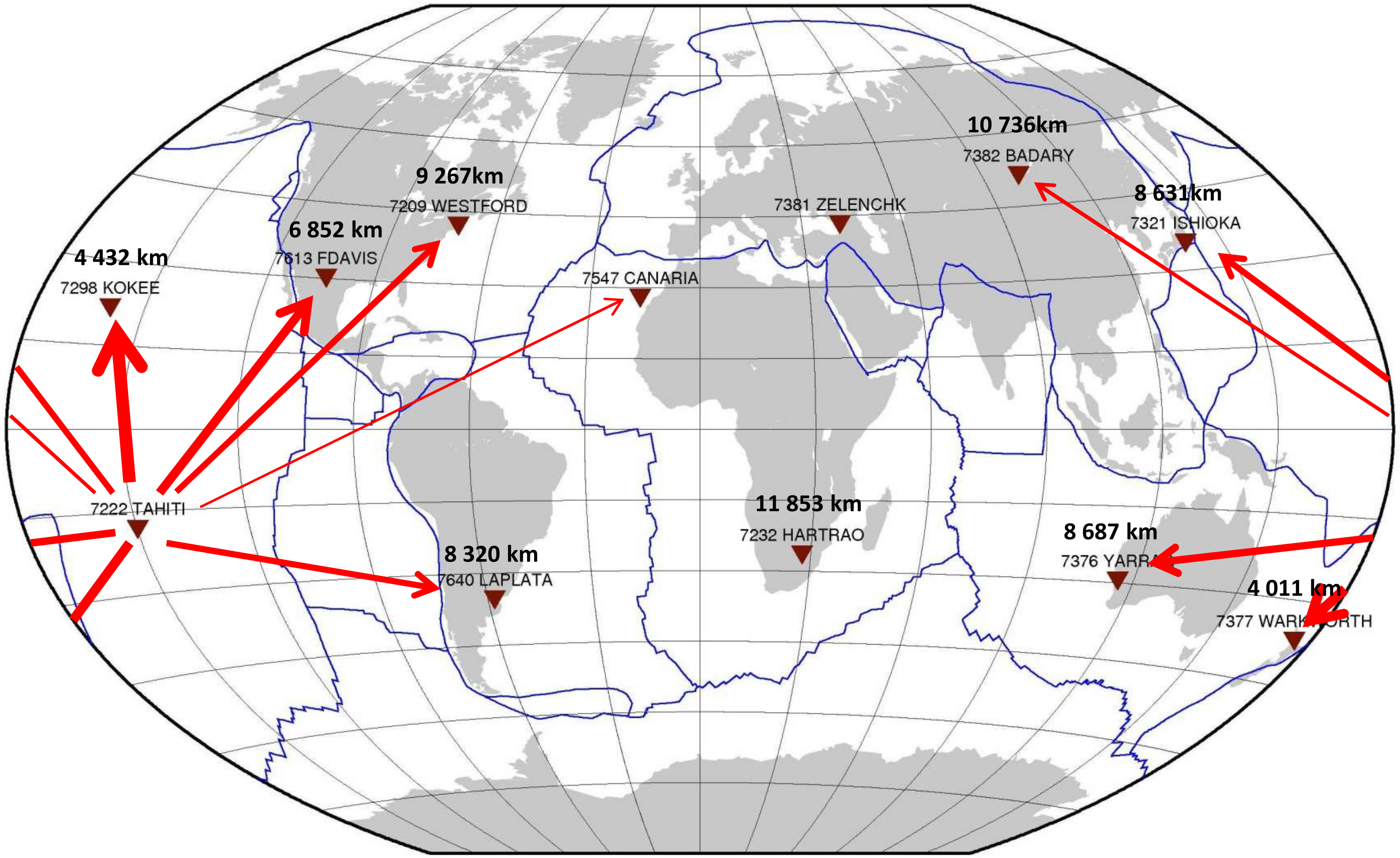
From 295 ICRF2 quasars used for the celestial reference frame orientation
we selected a set of 60 quasars equally distributed in right ascension and declination



# VLBI station network

Example of simulated data over one week from 12 stations and 60 quasars (~28 000 obs., ~4 800 obs. from Tahiti)

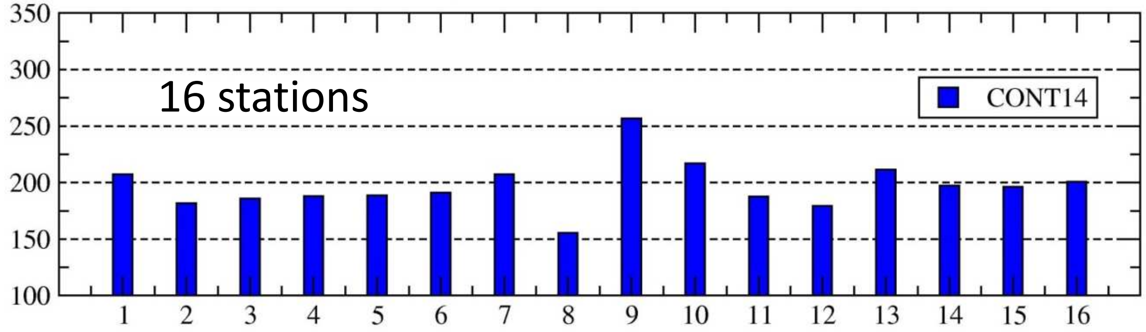
```
bases with Tahiti per week:
752 obs.   TAHITI - KOKEE       4431 km
715 obs.   TAHITI - WARKWORT    4011 km
667 obs.   TAHITI - FDAVIS      6851 km
472 obs.   TAHITI - YARRAG      8687 km
392 obs.   TAHITI - WESTFORD    9267 km
370 obs.   TAHITI - LAPLATA     8319 km
392 obs.   TAHITI - ISHIOKA     8630 km
 84 obs.   TAHITI - BADARY     10736 km
 15 obs.   TAHITI - CANARIA    11817 km
```

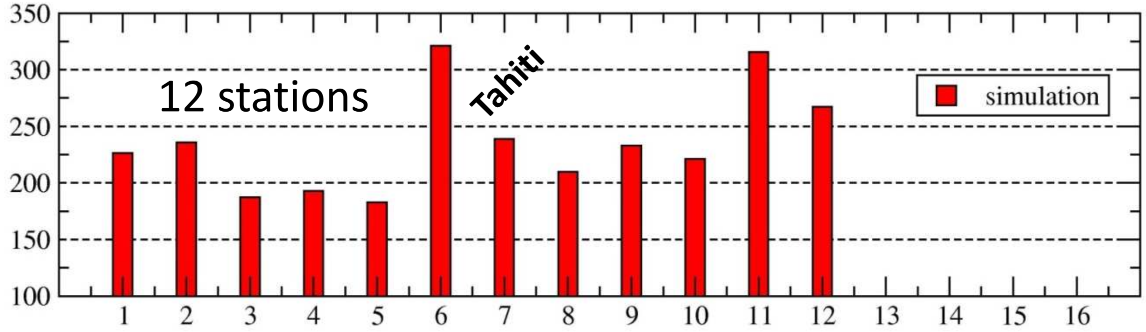


# Simulation vs. CONT’14 data

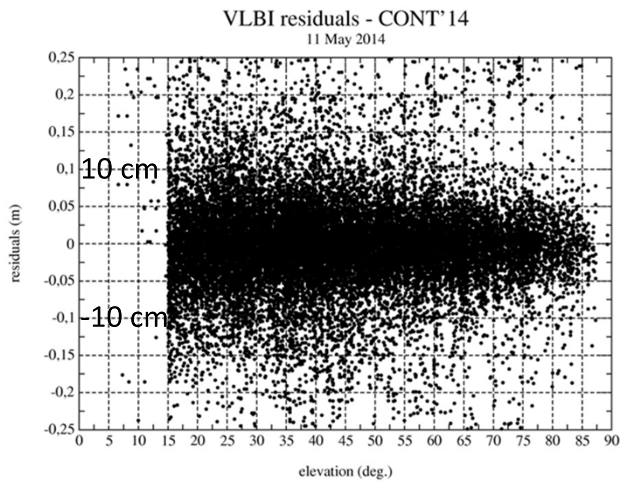
In order to be most realistic we considered equivalent observation density (one observation every ~200s in average per station) and simulated model errors giving similar results as for the CONT’14 campaign.

Mean scan interval (in sec.) per station over one week

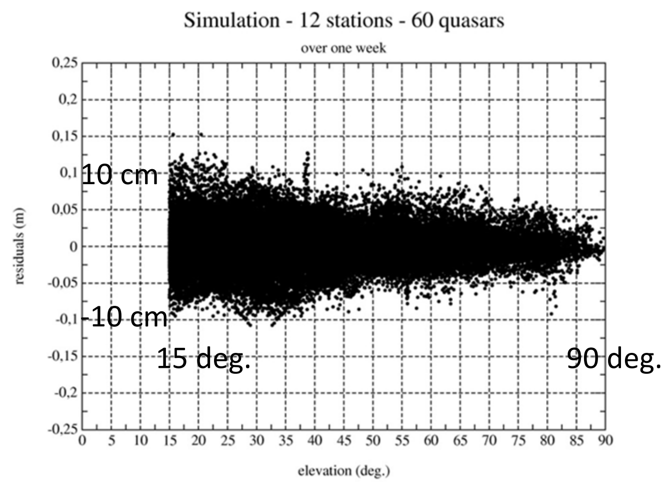



CONT’14 residuals / elevation angle




simulation residuals / elevation angle




Observations simulated every 90 s → 28 000 observations per week

# Simulated errors

A white **measurement noise** of 1.4 mm (at 1σ) was introduced on VLBI-type measurements. Moreover standard errors were introduced on following models or parameters:

1. **Stations coordinates**: 3 cm random at 1σ per X, Y, Z coordinate

| | X | Y | Z | Lat | Lon | H |
|---|---|---|---|---|---|---|
| 12 stations - mean (m) : | 0.023 | 0.012 | -0.014 | -0.017 | 0.002 | -0.005 |
| st. dev. (m) : | 0.012 | 0.029 | 0.036 | 0.035 | 0.030 | 0.031 |

2. **Quasars coordinates**: randomly according to the standard errors of ICRF2

| | Right Asc. (ms) | Decl. (mas) |
|---|---|---|
| 60 quasars - mean : | 0.002 | -0.007 |
| st. dev. : | 0.010 | 0.081 |

3. **Pole coordinates**: randomly according to the standard errors of IERC04

| | Xp (mas) | Yp (mas) | UT 1(ms) |
|---|---|---|---|
| over 8 weeks - mean : | 0.002 | 0.000 | -0.001 |
| st. dev. : | 0.042 | 0.044 | 0.015 |

4. **Troposphere models**: GPT/GMF vs. Hopfield with cut-off angle of 15 deg.

# Simulation synopsis

**Weekly processing** over 8 consecutive weeks:

- 12 stations with 15 deg. elevation cutoff
- 60 quasars
- ~28 000 VLBI measures/week (every 200 s in average at each station)

**VLBI residuals** per noise type introduced:

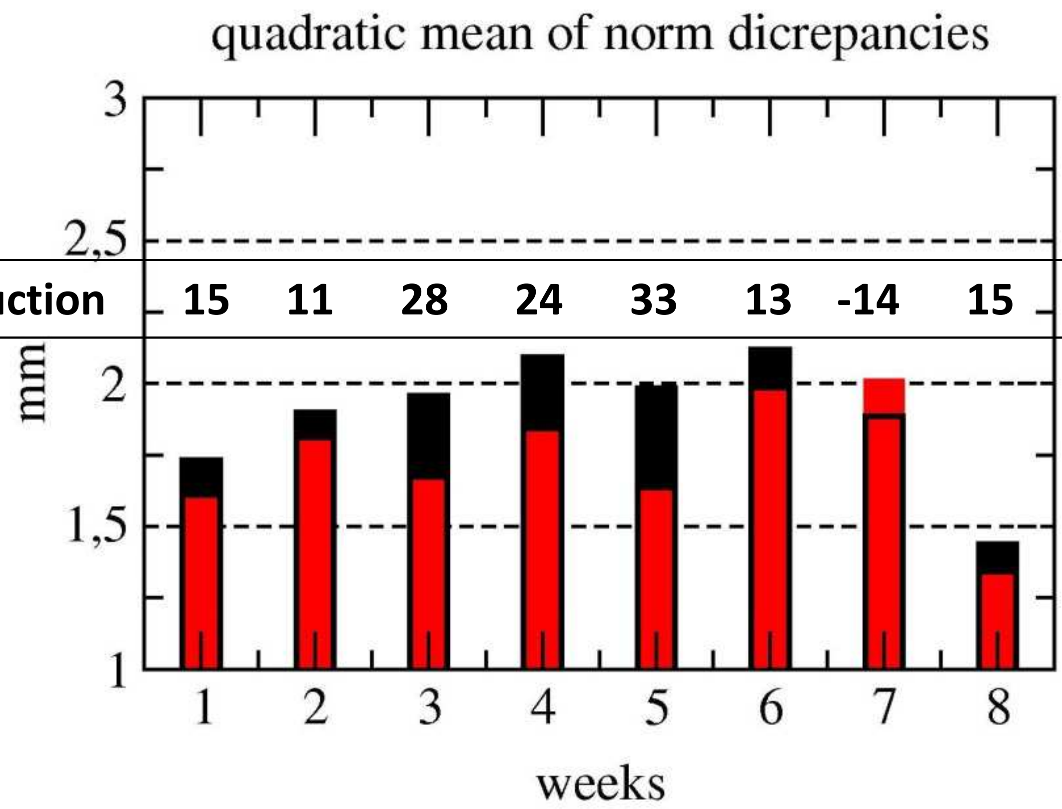
| | *before* (*1st iteration*) | / *after clock and troposphere adjustment* (*last iteration in processing*) |
|---|---|---|
| 1. Stations coordinates: | 37.3 mm / | 23.1 mm |
| 2. Quasars coordinates: | 2.9 mm / | 2.1 mm |
| 3. Pole coordinates: | 6.4 mm / | 4.8 mm |
| 4. Troposphere models: | 113.6 mm / | 2.0 mm |
| 5. Measurements: | 1.41 mm / | 1.37 mm |
| 6. All effects together | | **24.6 mm** (80 ps) |

**Adjusted parameters**:

Troposphere zenithal bias per 2 hrs (in pwl mode) → 8064 parameters
Clock offset per 2hrs (in pwl mode) → 7392 parameters
Pole coordinates per day (Px, Py, UT in pwl mode) → 171 parameters
Quasar coordinates for 60 quasars over 8 weeks (r. asc./decl.) → 120 parameters
Station coordinates for 12 stations per week (X, Y, Z) → 288 parameters

# TRF results

Stations coordinates are adjusted weekly considering or not a VLBI antenna in Tahiti. One notes a general improvement of the TRF with variance reduction factors of ~15% in average after adjustment.



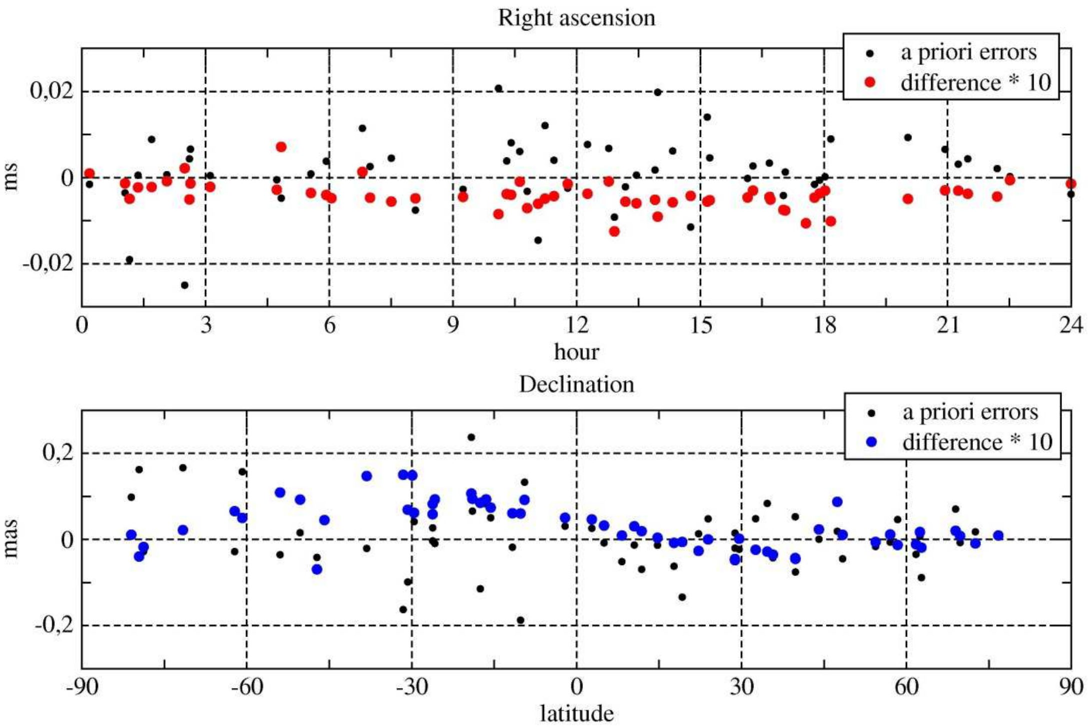

| | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| **Variance reduction** | **15** | **11** | **28** | **24** | **33** | **13** | **-14** | **15** | **(%)** |

# CRF results

Quasar coordinates are adjusted over the full 8-week test period with/without the Tahiti site.

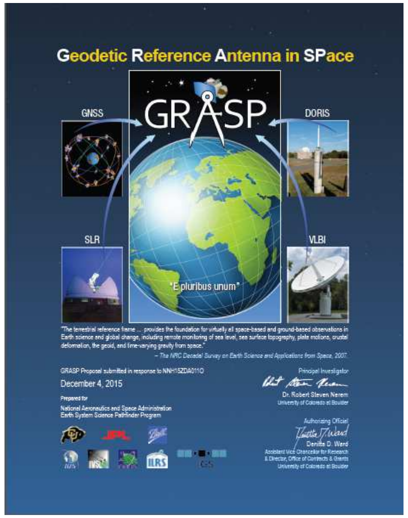
| rms / ref. | a priori noise | 11 sta. wo T | 12 sta. |
|---|---|---|---|
| R. asc. (ms) | .0105 | .0022 | .0025 |
| Decl. (mas) | .0810 | .0142 | .0106 |

CRF declination is mainly improved in the southern hemisphere

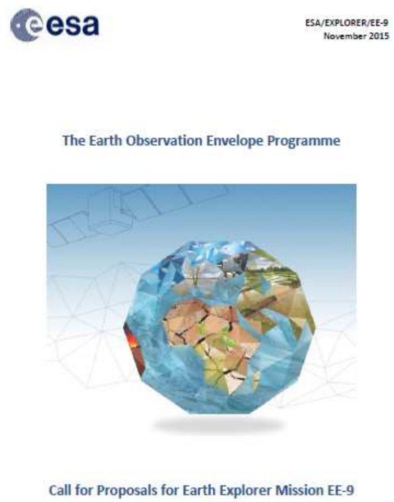


# Satellite-VLBI mission projects

*aiming at improving TRF to a precision of 1 mm and a stability of .1 mm/yr and homogenizing TRF/CRF/EOP*




- **GRASP**
  - NASA Earth Venture Mission-2 (2020)
  - Payload: TriG/SLR/VLBI transmitter
  - Orbit: 925 – 1400 km, sun-synchronous
  - Submitted on December 4, 2015




- **E-GRASP/Eratosthenes**
  - ESA Earth Explorer-9 mission (2024)
  - Payload: GNSS/DORIS/SLR/VT/µSTAR/T2L2
  - Orbit: ~900 – ~7200 km, sun-synchronous
  - To be submitted on June 24, 2016